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INFLUENCE OF SYNTHETIC POLYMER ON FRESH AND HARDENED PROPERTIES OF PSC CONCRETE WITH PARTIAL REPLACEMENT OF COARSE AGGREGATE BY CINDER AGGREGATE

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Abstract - *The construction chemicals are considered to be the fourth basic material of concrete due to its high advantage of improved workability and strength which are the main objectives of concrete. This study focuses on one of such chemicals which might be useful in construction activities in near future. A synthetic polymer i.e., polyvinyl alcohol (PVA) is used in concrete with partial replacement of natural granite coarse aggregate by cinder aggregate to know its properties. The fresh and hardened properties of cinder aggregate concrete with a varying quantity of synthetic polymer is studied for mix design of M25. The addition of synthetic polymer starts from 0% to 1% with an increment of 0.25%. The compressive strength is determined by casting cubes and curing for 7days and 28days. The tests are carried out as per Indian Standards (IS) and the results are discussed to reach the optimum dosage of the additive.*

Key Words: **Portland Slag Cement (PSC), Polyvinyl alcohol (PVA), Synthetic polymer, Cinder, Construction chemicals, Compressive strength, Workability.**

1. INTRODUCTION

Construction chemicals have to serve in improving the quality and utility of concrete and it can be done through various means. At present, a vast scope for research and development in the field of construction chemicals can be seen. Construction chemicals are used to increase the workability and strength of concrete as it acts as water retaining or binding agent etc. Due to the availability of chemicals with different properties and abilities are significant, for the selection of the appropriate type, one needs to be chosen according to the requirement of the specific condition. Here, Polyvinyl alcohol, a white coloured synthetic polymer in crystalline form is selected due to its binding and water-retaining ability. The effect of Polyvinyl alcohol for adaptability and feasibility of concrete is studied by varying its quantity.

Our Environment is being polluted every day. One of the main reasons behind this pollution is the generation of industrial wastes. With the advent of Industrial development and mass constructions in various parts of the world, a lot of harmful chemicals and other wastes are dumped in an improper way polluting the atmosphere. Because of the population explosion, the large number of infrastructural development is required, a large number of construction materials are required for this infrastructural growth which is creating a scarcity of natural construction materials in the urban areas, due to the scarcity of construction materials, the cost of construction materials are increasing. On the other hand, awareness has to be created among the people about the scarcity of construction materials and the appropriate construction technologies coming in the market. Appropriate technologies refer to materials, methods, and practices which help to protect the natural environment, by making use of local resources and contribute to local economic development. Iron manufacturing companies produce large amounts of by-product namely Cinders. In the present day construction, it is used as a bottom or sub grade aggregate in floorings as well as washrooms in buildings and pavement construction. Hence the use of cinders which is an industrial waste material as coarse aggregate gains its importance in the construction industry. In the present study, the natural granite coarse aggregates are partially replaced by cinder aggregate for mix design of M25 grade concrete with an addition of synthetic polymer to know the strength and its workability.

2. LITERATURE REVIEW

E Hanuman Sai Gupta and V Giridhar Kumar [7] have studied on use of cinder as coarse aggregate as a replacement of granite aggregate. The concrete mix design of M25 grade concrete with a water-cement ratio of 0.45 was adopted. Cinder aggregate concrete with a replacement level of 40% of cinder achieved the equal target mean strength as conventional concrete. V Bhaskar Desai and A Sathyam [8] have studied on strength properties of light weight cinder aggregate concrete. It is concluded that the cube compressive strength is decreased continuously with the increase in percentage of cinder. However, even with 75% replacement of conventional aggregate by cinder aggregate, more than target mean strength of concrete is achieved. Trung Nghia Tran [9] have studied the production of synthetic mineral polymer brick comprising sand, cement and polymer additives. The polymer additives can be used in the batching are HPMC (Hydroxy Propyl Methyl Cellulose), PVA (Polyvinyl Alcohol), and CMC (Carboxyl methyl cellulose). By using polymers as additives the benefits

achieved are improved quality, low cost, and energy efficient.

By referring to the above studies conducted by various researchers, for M25 grade concrete the natural granite coarse aggregates can be replaced by cinders up to 40% to achieve target mean strength. The PVA (Polyvinyl Alcohol) can be utilized as it is cost - efficient and acts as water retaining agent.

3. OBJECTIVES

1. To study the fresh and hardened properties of PSC concrete with partial replacement of natural granite coarse aggregate by 40% cinder aggregate in addition to the synthetic polymer.
2. To determine the optimum dosage of PVA (Polyvinyl Alcohol) for which maximum strength and good workability can be achieved.

4. EXPERIMENTAL STUDIES

4.1 Materials

The materials used in this study are Portland Slag cement (PSC) confirming to IS 455: 2015 with specific gravity 3.03 and fineness 2.6%. M Sand confirming to Zone II with specific gravity 2.55 and water absorption 3.09%.

Crushed granite aggregate confirming to a graded aggregate of nominal size 20mm with specific gravity 2.62 and water absorption of 0.6%. Cinder aggregate confirming to a graded aggregate of nominal size of 20mm with specific gravity 2.42 and water absorption of 3.15%. Polyvinyl alcohol, a synthetic polymer with a degree of hydrolyzation 86%.

4.2 Methodology

For this study, mix design of M25 grade is carried out as per IS 10262: 2009 by adopting water-cement ratio as 0.45 and the mix ratio obtained is 1(cement): 1.49(sand): 2.34(Coarse Aggregate). The granite coarse aggregate is replaced by 40% of cinder aggregate. The percentage addition of synthetic polymer is varied to the concrete from 0% to 1% with an increment of 0.25%. The percentage of polymer is taken with reference to the weight of cement and is pre-dissolved in water before adding to the mixing of concrete. Cinders are presoaked over a night and brought to surface dry condition. The fresh properties are determined by slump test, compaction factor test, and vee – bee test as per IS 1199: 1959. The cubes are cast and cured for 7days and 28days to determine its strength. The mix proportion carried out are shown in Table 1.

Table -1: Mix proportions

Sr. No	Type	Percentage of polymer (%)	Cement (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	
					Granite	Cinder
1	M0.00	0.00	438	654	631	388.5
2	M0.25	0.25	438	654	631	388.5
3	M0.50	0.50	438	654	631	388.5
4	M.075	0.75	438	654	631	388.5
5	M1.00	1.00	438	654	631	388.5

5. RESULTS AND DISCUSSION

5.1 Influence on Fresh Concrete Properties

The results of fresh concrete properties are tabulated in Table 2. Chart 1, 2 and 3 shows the variation of a slump, compaction factor, and vee – bee time with an increase in the percentage of polymer respectively.

Table -2: Fresh Concrete Properties

Sr. No	Designation	Slump (mm)	Compaction Factor	Vee – Bee time (s)
1	M0.00	30	0.814	28
2	M0.25	48	0.843	21
3	M0.50	78	0.912	16
4	M.075	83	0.922	12
5	M1.00	105	0.934	9

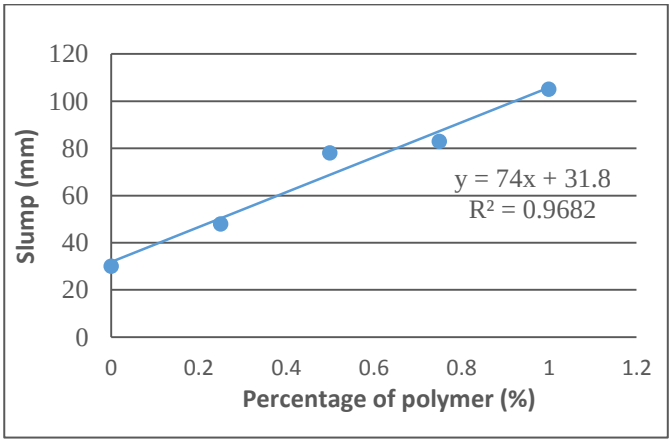

Chart -1: Variation of slump with an increase in the percentage of polymer

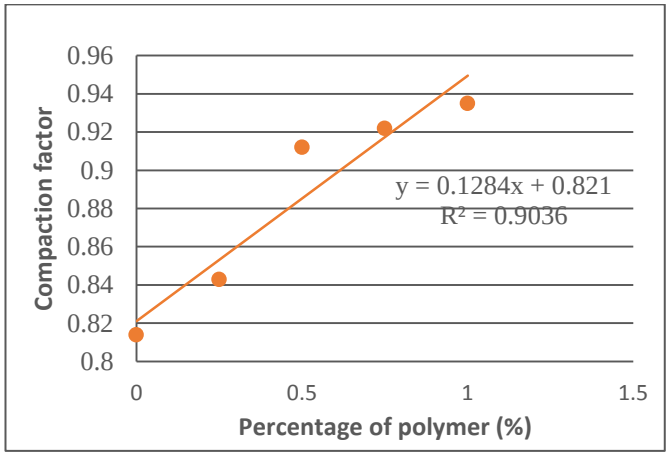

Chart -2: Variation of compaction factor with an increase in the percentage of polymer

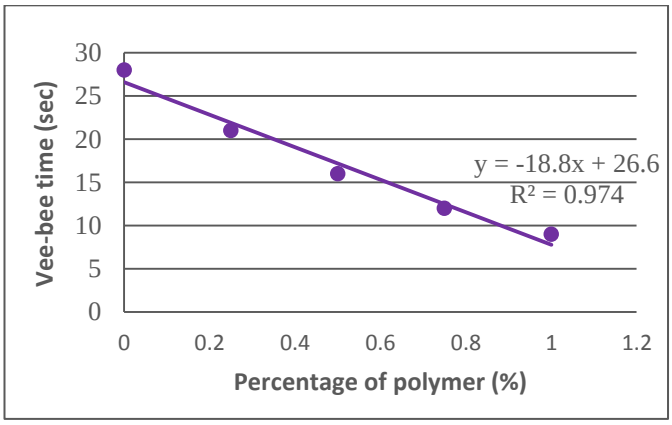

Chart -3: Variation of vee – bee time with an increase in the percentage of polymer

From chart 1, 2 and 3, it can be observed that the workability gradually increases with an increase in the percentage of polymer till 1%. The linear relationship is established between Slump, compaction factor and vee-bee time with a percentage of polymer respectively and the correlations are given in the following equations as

Slump = 74x + 31.8 ..... Eq. 1

Compaction factor = 0.1284x + 0.821 ..... Eq. 2

Vee-bee time = -18.8x + 26.6 ..... Eq. 3

Where, x = Percentage of polymer.

5.2 Influence on Hardened Concrete Properties

The results of compressive strength of concrete cubes at 7 days and 28 days are tabulated in Table 3. Chart 4 shows the compressive strength of cinder replaced concrete with the polymer at 7 days and 28 days. Chart 5 shows the variation of Compressive strengths with an increase in the percentage of polymer at 7 days and 28 days.

Table -3: Compressive strength

Sr. No	Designation	Average Compressive Strength (MPa)	
		7 days	28 days
1	M0.00	20	30.66
2	M0.25	18.67	25.77
3	M0.50	15.55	25.33
4	M.075	17.33	25.77
5	M1.00	18.67	28.89

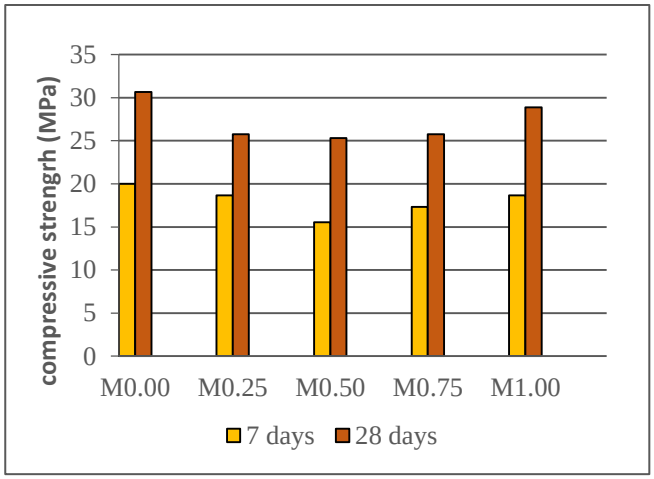

Chart -4: Compressive strength of cinder replaced concrete with polymer

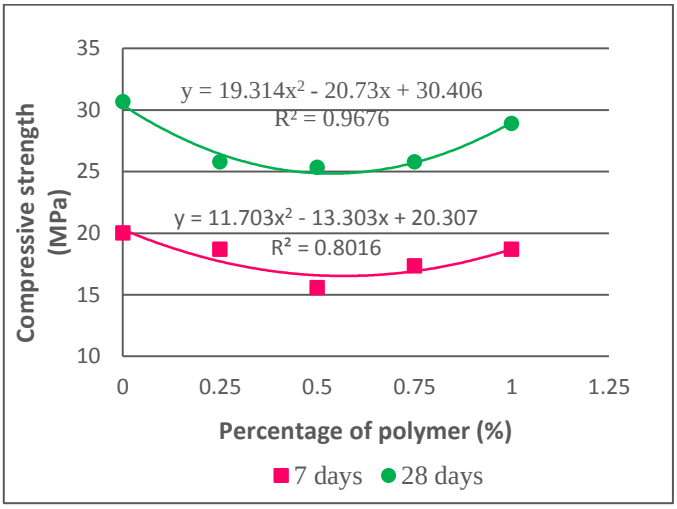

Chart -5: Variation of Compressive strengths with an increase in the percentage of polymer

From chart 4, it can be observed the strength gained from 7 days to 28 days is between 60% to 72%. The 7 days and 28 days strength is maximum in M0.00 i.e. with no polymer addition and is minimum in M0.50 i.e. with 0.5% polymer.

From chart 5, it can be inferred that

i. The 7 days and 28 days strength of concrete with 60% granite aggregate and 40% cinder aggregate shows curvilinear variation with an increase in percentage of polymer.
ii. The strength is more when no polymer is added i.e., 30.66 MPa at 28days.
iii. The strength starts decreasing from 0% of polymer to 0.5% polymer i.e., from 30.66 MPa to 25.33 MPa and then onwards it increases till 1% of polymer.
iv. The strength at 1% of polymer is 28.89 MPa at 28 days.
v. The correlation established between cinder aggregate concrete and percentage polymer is

$$Y1 = 19.314x^2 - 20.73x + 30.406 \quad \text{Eq. 4}$$

$$Y2 = 11.703x^2 - 13.303x + 20.307 \quad \text{Eq. 5}$$

Where, x = Percentage of polymer
Y1 = Compressive strength at 7 days
Y2 = compressive strength at 28 days

6. CONCLUSIONS

The following conclusions were drawn from the above investigation.

1. The workability of concrete gets increased with increase in polymer content.
2. The relationship between a slump, compaction factor and vee-bee time with the percentage of polymer is linear.
3. The strength of concrete with 60% granite aggregate and 40% cinder aggregate shows curvilinear variation with an increase in the percentage of polymer.
4. Strength is more at 0% of the polymer and starts decreases and reaches to minimum at 0.5% of polymer and there after it increases till 1% of polymer for both at 7 days and 28 days.
5. For all the combinations, the strength at 28 days is more than 25 MPa.

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